Delay Tolerant, Radio Frequency Identification (RFID)-enabled Sensing

Radio Frequency Identification (RFID) technology offers a completely passive method to transmit fixed data sequences from an RFID tag, which typically doesn't have its own power supply, to an interrogator. Radio frequency (RF) energy harvested from the interrogator is rectified by the tag and used to charge an integrated circuit (IC). The IC then modulates the received signal with the data stored on the tag and reflects the energy back to the interrogator. RFID has seen great proliferation in terrestrial inventory management applications, and it has recently made the jump to spaceflight applications onboard the International Space Station, augmenting an existing optical bar-code infrastructure for tracking supplies.

A number of advanced automated logistics management (ALM) concepts employing RFID are currently being developed and evaluated, including so-called "smart" shelves, cubbies, and trash receptacles using low-power, embeddable RFID interrogators. An infrastructure where both crew members and robotic assistants, such as autonomous free flyers, are similarly equipped with small RFID interrogators seems likely. It therefore behooves us to consider extending this infrastructure beyond ALM to applications such as low power, embedded sensing.

Typically, data on an RFID tag can only be written by an RFID interrogator, using interrogator energy. In recent years, however, a few efforts have focused on using that energy to drive data acquisition from the tag IC, allowing the tag to modify its stored data sequence with sensor data before replying to an interrogator. In this way, the tag can act as a completely passive sensing device.

One problem exists with this approach, however: the tag cannot gather data when an interrogator is not present. Thus, strictly passive RFID sensing tags cannot gather data at regular intervals, in the manner of a typical wireless sensor network, without careful, and impractical, planning of mobile interrogator movements. To address this shortcoming, we look to a recent advance in RFID technology which allows an external microprocessor to power the tag IC and write directly into its RFID memory using a wired serial interface. In this paradigm, data gathering is driven by a small, on-board power supply (using batteries or harvested energy), and data transfer is provided passively through the RFID interrogation service. Since communication typically consumes the lion's share of power in WSNs, such a technique has the potential to enable extremely long-lived, embedded wireless sensing when used with extremely low-current microcontrollers.

Since the communication channel is only open when an interrogator is present and actively interrogating the RFID sensing tag, transport of periodically-sampled sensor data presents itself as a delay/disruption-tolerant networking (DTN) problem. In this paper, we present the design of a DTN-like overlay on the common EPC Global, Class 1, Generation 2 RFID standard. This overlay allows seamless, guaranteed data transfer using the EPC Global protocol, supporting extremely low-power, embedded sensing using an infrastructure likely to be already in place for ALM applications. We evaluate a prototype implementation of a complete end-to-end system using a robotic RFID interrogation agent, and we present future directions for the development of this sensing technique.